

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Inventor(s): Laura Wills Mirkarimi Confirmation No.: 1183
Application No.: 10/765,647 Examiner: Duy Vu Nguyen Deo
Filed: January 26, 2004 Group Art Unit: 1765
Title: METHOD FOR ETCHING HIGH ASPECT RATIO FEATURES IN III-V BASED
 COMPOUNDS FOR OPTOELECTRONIC DEVICES

Attorney Docket No.: 10030753-1

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

BRIEF ON APPEAL

Sir:

This Brief on Appeal is in furtherance of Applicant's Notice of Appeal filed April 14, 2008 appealing the final rejection, dated December 13, 2007, of Claims 1-20. Applicants thank the USPTO for the Pre-Appeal Brief Conference resulting in the Decision mailed May 14, 2008

A copy of the Claims appears in the Appendix to this Appeal Brief.

REAL PARTY IN INTEREST (37 C.F.R. §41.37(c)(1)(i))

Pursuant to 37 C.F.R. §41.37(c)(1)(i), the real party in interest in this appeal is: Agilent Technologies, Inc.

RELATED APPEALS AND INTERFERENCES (37 C.F.R. §41.37(c)(1)(ii))

Pursuant to 37 C.F.R. §41.37(c)(1)(ii), there are no appeals or interferences that will directly affect, or be directly affected by, or have bearing on, the Board's decision in the pending appeal.

STATUS OF CLAIMS (37 C.F.R. §41.37(c)(1)(iii))

Pursuant to 37 C.F.R. §41.37(c)(1)(iii), the status of the claims is as follows:

A. TOTAL NUMBER OF CLAIMS IN THE APPLICATION

Claims in the Application are 1-20.

B. STATUS OF ALL CLAIMS IN APPLICATION

1. Claims cancelled: NONE
2. Claims withdrawn from consideration but not cancelled: NONE
3. Claims pending: 1-20
4. Claims allowed: NONE
5. Claims rejected 1-20

C. CLAIMS ON APPEAL

The claims stand as originally filed. (See the Claims Appendix, below.) The Claims on Appeal are: 1-20.

STATUS OF AMENDMENTS

Pursuant to 37 C.F.R. §41.37(c)(1)(iv), the status of amendments is as follows:

No Amendments are pending.

SUMMARY OF CLAIMED SUBJECT MATTER

Pursuant to 37 C.F.R. §41.37(c)(1)(v), the claimed invention is directed to a method for combining Reactive Ion Etching (RIE) with bromine based chemistry to etch III-V based compounds such as InP. Mixtures of HBr with CH₄ and H₂ provide fast etch rates, vertical sidewalls and good control over the growth of polymers that arise from the presence of CH₄ in the mixture. In accordance with the invention, HI or IBr or some combination of group VII gaseous species (Br, F, I) may be substituted for HBr. Typical values in accordance with the invention for mixtures of HBr, CH₄ and H₂ are HBr in the range of about 2 to 75 percent, CH₄ in the range of about 5 to 50 percent and H₂ in the range of about 5 to 40 percent by volume at pressures in the range from about 1 to 30 mTorr.

A method for etching high aspect ratio features in III-V based compounds for optoelectronic devices in accordance with the invention is described starting on page 3, line 1 of the specification, shown in FIGs. 1a-c. The method as recited in Claim 1 for etching a III-V semiconductor material (110) comprises placing a semiconductor substrate (105) on which the III-V semiconductor material (110) has been deposited into a reactive ion etching reactor (205); introducing a first gas chosen from HBr, HI and IBr into the reactive ion etching reactor (205), introducing a second gas of CH₄ into the reactive ion etching reactor (205), introducing a third gas of H₂ and exposing a portion of the III-V semiconductor material (110) to be etched to a mixture comprising the first, the second and the third gas.

GROUND OF REJECTION TO BE REVIEWED ON APPEAL

Pursuant to 37 C.F.R. §41.37(c)(1)(vi), the grounds of rejection to be reviewed on appeal are as follows:

Claims 1-20 are rejected under 35 U.S.C. 103 (a) as being unpatentable over Fathimulla et al. (U.S. Patent No. 5,338,394) and further in view of Pearton et al. (Applied Physics Letters 60 (7)).

ARGUMENT (37 C.F.R. §41.37(c)(1)(vii))

Pursuant to 37 C.F.R. §41.37(c)(1)(vii), Applicants, by and through their undersigned Attorney, make the following arguments with respect to the above-cited grounds for rejection:

I. RELEVANT LAW

As stated in MPEP § 2143, in order to establish a *prima facie* case of obviousness, three basic criteria under 35 U.S.C. § 103 must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.

The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art and not based on applicant's disclosure. In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

Against this background the obviousness or nonobviousness of the subject matter is determined. Such secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. While the sequence of these questions might be reordered in any particular case, the factors continue to define the inquiry that controls.

If a court, or patent examiner, conducts this analysis and concludes the claimed subject matter was obvious, the claim is invalid or unpatentable under § 103. *KSR Int'l Co. v. Teleflex Inc.*, 127 S. Ct. 1727; 82 U.S.P.Q.2D 1385 (2007), citing, in part *Graham v. John Deere Co.*, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966).

However, the Court in *KSR* continued: "A factfinder should be aware, of course, of the distortion caused by hindsight bias and must be cautious of arguments reliant upon *ex post* reasoning. See *Graham*, 383 U.S., at 36, 86 S. Ct. 684, 15 L. Ed. 2d 545 (warning against a "temptation to read into the prior art the teachings of the invention in issue" and instructing courts to "'guard against slipping into the use of hindsight'" (quoting *Monroe Auto Equipment Co. v. Heckethorn Mfg. & Supply Co.*, 332 F.2d 406, 412 (CA6 1964)))." Moreover, if there is no suggestion to combine the teachings of the applied art, other than the use of Applicants'

invention as a template for its own reconstruction, a rejection for obviousness is improper. *Ex parte Crawford, et al.* Appeal 20062429, May 30, 2007.

The Court in *KSR* further explained that when the prior art teaches away from a combination, that combination is more likely to be nonobvious. Notably, the Court relied on the Federal Circuit's statement, in *In re Gurley*, as follows:

"A reference may be said to teach away when a person of ordinary skill, upon reading the reference, *would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant* . . . [or] *if it suggests that the line of development flowing from the reference's disclosure is unlikely to be productive of the result sought by the applicant.*" *In re Gurley* 27 F.3d 551, 553, 31 USPQ2d 1130, 1131 (Fed. Cir. 1994).

II. THE CITED REFERENCES MAY NOT PROPERLY BE COMBINED TO ATTEMPT TO MAKE A PRIMA FACIE SHOWING OF OBVIOUSNESS, BECAUSE THE REFERENCES DO NOT SUGGEST OR MOTIVATE THEIR COMBINATION. RATHER, THE PRIOR ART CITED IN SUPPORT OF THE REJECTION ACTUALLY TEACHES AWAY FROM THE CLAIMED INVENTION

i. Claims 1 and 12

Claim 1 is drawn to a method of etching III-V semiconductor material, and features:

"...introducing a first gas chosen from HBr, HI and IBr into said reactive ion etching reactor; introducing a second gas of CH₄ into said reactive ion etching reactor; introducing a third gas of H₂; and exposing a portion of said III-V semiconductor material to be etched to a mixture comprising said first, said second and said third gas."

As such, among other aspects, the method of claim 1 includes: introducing a first gas into an RIE reactor and introducing **methane (CH₄)** into the reactor and introducing H₂.

Claim 12 is drawn to a method for etching a III-V semiconductor substrate and includes the noted features. Thus, **claims 1 and 12 each feature** the use of introducing 1. **HBr**; and 2. **CH₄**; 3. and H₂.

ii. Fathimulla, et al. teaches away

Claim 1 is drawn to a method for etching III-V semiconductor material and features:

“...introducing a first gas chosen from HBr, HI and IBr into said reactive ion etching reactor;

introducing a second gas of CH₄ into said reactive ion etching reactor;

introducing a third gas of H₂; and

exposing a portion of said III-V semiconductor material to be etched to a mixture comprising said first, said second and said third gas.”

As such, among other aspects, the method of claim 1 includes: introducing a first gas into an RIE reactor, and introducing methane into the reactor and introducing H₂. Claim 12 is drawn to a method for etching a III-V semiconductor substrate and includes the noted features.

The comments in support of the rejection argue as follows:

Fathimulla describes a method for etching an III-V material comprising: placing the III-V substrate into a RIE chamber and etching the substrate with a gas mixture of HBr and CH₄ (claims 1-4). Unlike claimed invention, Fathimulla doesn't describe the gas mixture having H₂. Pearton teaches a method for etching III-V material wherein the gas mixture includes H₂ (pages 839; left column). It would have been obvious for one skilled in the art at the time of the invention to modify Fathimulla in light of Pearton by including H₂ in the gas mixture because Pearton teaches addition of the H₂ to the gas mixture provide a much smoother surfaces and Fathimulla teaches that other combinations of gas composition can be used to give a smooth vertical feature (col. 3, line 65-68).

A review of portions of *Fathimulla, et al.* relied upon in the rejection does reveal the use of HBr as an alternative to SiCl₄ in a mixture of methane; or the use of HBr as an alternative to SiCl₄ in a mixture of H₂.

By contrast, claims 1 and 20 teach the use of introducing HBr, methane and H₂.

A person of ordinary skill in the art would be would be led by the disclosure of *Fathimulla, et al.* in a direction divergent from the path that was taken by the Applicant. Namely,

not to introduce both methane and H₂ into the RIE reactor, but rather to introduce either methane or H₂.

Accordingly, the applied reference to *Fathimulla, et al.* teaches away from the claimed invention, and, therefore, is an example of the sort of reference contemplated by the Court in the *KSR* opinion discussed above, which is not properly the basis for an obviousness rejection.

As such, and for at least the reasons set forth above, because *Fathimulla, et al.* teaches away, reliance thereon renders the rejection for obviousness improper. Withdrawal of this rejection is earnestly solicited.

iii. Pearton, et al. teaches away

The Examiner concedes that the reference to *Fathimulla, et al.* fails to disclose the use of H₂ in the gas mixture. (As noted previously, the reference to *Fathimulla, et al.* discloses the use of HBr and methane, or HBr and H₂. Thus, the mixture of HBr, methane and H₂ is not disclosed in the reference; and for reasons set forth above, teaches away from this combination.)

The Examiner then turns to *Pearton, et al.* in an attempt to cure this defect. However, *Pearton, et al.* discourages the use of methane/ H₂ mixtures. Notably, the reference states:

“The major limitation with the use of CH₄/H₂ discharges is the slow etch rates... [and] Several attempts to enhance the CH₄/H₂ etch rates by addition of Cl₂ (Ref. 9) and PCl₃ (Ref. 10) have been reported, but relatively high self-biases were needed to achieve practical etch rates and careful seasoning of the reactor necessary for reproducible results.”

The reference then touts the use of an HI/H₂ discharge as having much faster etch rates than CH₄/ H₂. Accordingly, Applicants respectfully submit that one of ordinary skill in the art would be discouraged from seeking to introduce methane and H₂ in the RIE reactor as set forth in claims 1 and 20.

Therefore, the applied reference to *Pearton, et al.* teaches away and cannot serve as a reference in a rejection of the claims under present consideration. (Applicants refer to page 838, left column of the reference to *Pearton, et al.* for support for their position.)

iv. *Fathimulla, et al.* cannot be combined with *Pearton, et al.*

Applicants respectfully submit that the required suggestion or motivation to combine references is lacking because *Fathimulla, et al.* teaches away from its combination with *Pearton, et al.* Notably, there is no suggestion to combine if a reference teaches away from its combination with another source:

"A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant." *In re Gurley*, 27 F.3d 551, 553 (Fed. Cir. 1994); *see KSR*, 127 S. Ct. at 1739-40 (explaining that when the prior art teaches away from a combination, that combination is more likely to be nonobvious).

A review of portions of *Fathimulla, et al.* relied upon in the rejection does reveal the use of HBr as an alternative to SiCl₄ in a mixture of CH₄; or the use of HBr as an alternative to SiCl₄ in a mixture of H₂. As such, the reference discloses the use HBr and CH₄; or HBr and H₂. Thus, with all three compounds at their disposal, *Fathimulla, et al.* do not direct one skilled in the art to combine all three, but rather direct one skilled in the art to limit the mixture to HBr and one or the other of CH₄ or H₂.

As such, Applicants respectfully submit that one skilled would be not be led in a direction of the path taken by Applicants, but instead would be led in a direction divergent from the path that was taken by Applicants. Thus, Applicants respectfully submit that the reference to *Fathimulla, et al.* teaches away from the use of all three compounds, HBr and CH₄ and H₂. Because the reference to *Fathimulla, et al.* teaches away, its combination with another reference is nonobvious, and thus an obviousness rejection based thereon is improper.

v. *Pearton, et al.* cannot be combined with *Fathimulla, et al.*

As noted at page 5 of the Rule 116 Response, the Office Action concedes the lack of disclosure in *Fathimulla, et al.* of introducing HBr and CH₄ and H₂. In an attempt to remedy the shortcomings of the primary reference, the Office Action turns to *Pearton, et al.* However, *Pearton, et al.* explicitly discourages the combination of CH₄ and H₂. As noted at page 6 of the Rule 116 Response, *Pearton, et al.* states (with emphasis added):

"The major limitation with the use of CH₄/H₂ discharges is the slow etch rates... [and] Several attempts to enhance the CH₄/H₂ etch rates by addition of Cl₂ (Ref. 9) and PCI₃ (Ref. 10) have been reported, but relatively high self-biases were needed to

achieve practical etch rates and careful seasoning of the reactor necessary for reproducible results.” (See page 838, left column.)

Furthermore, at page 839, right column, *Pearton, et al.* states (again, with emphasis added):

“With CH₄/H₂ mixtures at high microwave powers, the InP surface becomes rapidly deficient in phosphorous, and the morphology for even small (< 2000 Å) etch depths is unacceptable.”

So, if one were looking to supplement the two-gas mixture of HBr and CH₄ disclosed in *Fathimulla, et al.*, a study of *Pearton, et al.* would clearly discourage one from combining CH₄ and H₂. Therefore, one skilled in the art would be discouraged from introducing the compounds HBr and CH₄ and H₂ as claimed.

III. APPLYING THE CITED REFERENCES TO SUPPORT A PRIMA FACIE SHOWING OF OBVIOUSNESS OF THE CLAIMED INVENTION IS AN ACT OF IMPERMISSIBLE HINDSIGHT

Applicants respectfully submit that impermissible hindsight has been used in an attempt to cobble a rejection from piece-parts garnered selectively from the applied art and reconstructed from the template of the claims themselves.

To this end, claims 1 and 12 include the introduction of a first gas, and methane and H₂ to a RIE chamber.

The primary reference discloses the use of either methane or H₂ with HBr, which is one possible ‘first gas.’ The Examiner then selectively selects two of the gases, HBr and methane, and recognizing that the third gas is missing turns to the secondary reference for the teaching of the missing third gas, H₂.

However, as noted above, not only does the secondary reference not encourage the combining of H₂ with methane, as the Examiner attempts to do, but also, the reference to *Pearton, et al.* discourages this combination in favor of another combination.

Respectfully, Applicants assert that the one and only way that one skilled in the art would select the combinations as the Examiner suggests is if the artisan had Applicants claims as templates for their reconstruction. Otherwise, the artisan would be led in a different direction by *Fathimulla, et al.* (i.e., to use either methane or H₂) than claims 1 and 12; and would be discouraged by *Pearton, et al.* from combining methane and H₂.

Since there is no suggestion to combine the teachings of the applied art, other than the use of Applicants' invention as a template for its own reconstruction, a rejection for obviousness is improper. In the present rejection, for at least the reasons set forth above, the combination not only does not suggest the introducing of HBr and CH₄ and H₂, but also the combination discourages it.

Therefore, but for the use of Applicants' claims as a template for their own reconstruction, the proffered combination of references could not be made. As such, the rejection relies on impermissible hindsight, and is wholly improper.

IV. RESPONSE TO ARGUMENTS FOR REJECTION IN THE ADVISORY ACTION

The Advisory Action includes various rebuttals of Applicants' positions regarding the impropriety of the rejections. Applicants address these rebuttals presently.

The Examiner rebukes Applicants' position that *Fathimulla, et al.* teaches away by leading one skilled in the art in a divergent path from the path taken by Applicants. To wit, the Examiner states:

“Applicant's [sic] pointing out the slow etch rates of using CH₄/H₂ by Fathimulla is acknowledged. However, this is found unpersuasive because the slow etch rates are not a major concern of Fathimulla, who teaches to use other gases to achieve a smooth vertical surface...”

First, it would seem that the Examiner is discounting the discouraging of the use of CH₄ and H₂ as provided in *Fathimulla, et al.* because the teachings of *Fathimulla, et al.* are allegedly focused on other aspects of semiconductor processing.

Respectfully, Applicants submit that the ‘concerns’ of a reference are irrelevant to the present inquiry as they are not related to the path taken by Applicants and have no basis in the law as it relates to whether a reference teaches away. Rather, the inquiry is whether one skilled in the art at the time of Applicants inventions would have been discouraged from following the

path set out in the reference, or would have been led in a direction divergent from that which is claimed upon review of a reference offered in combination in an obvious-type rejection.

As the Examiner concedes, and as discussed above and in the 116 Response, the concerns raised in *Fathimulla, et al.* regarding the slow etch rates garnered by combining CH₄ and H₂ would have discouraged the artisan of ordinary skill from using this combination of gases, and would lead one skilled in the art in a direction divergent from the path taken by Applicants (i.e., introducing CH₄ and H₂ as claimed).

For at least these reasons, Applicants maintain that the reference teaches away from the claimed invention.

Second, the Examiner asserts that the etch rates can be enhanced by increased bias, among other things. This is discussed at column 3, line 65 through column 4, line 5 of *Fathimulla, et al.* The methods described in the reference as being used to enhance etch rates are only discussed in the context of enhancing etching with SiCl₄ and CH₄ or SiCl₄ and H₂; and no case is there even a suggestion of the enhancing etch rates using CH₄ and H₂. Moreover, there cannot possibly be such a teaching or suggestion of enhancing etch rates with the combination of CH₄ and H₂ because there is no teaching of etching with the combination of these gases in the first place.

As such, the Examiner's attempt to rehabilitate the teachings of *Fathimulla, et al.* that discourage the path taken by Applicants are misplaced and unfounded in law.

CONCLUSION AND PRAYER FOR RELIEF

For at least the reasons set forth above, Applicants respectfully submit that the rejection of claims 1 and 12 under 35 U.S.C. § 103 is improper and that claims 1 and 12 are patentable over the applied art. Moreover, and for at least the same reasons, the rejections of claims 2-11 and 13-20, which depend from claims 1 and 12, respectively, are also improper and these claims are patentable for at least the same reasons.

It is respectfully requested that the Board of Patent Appeals and Interferences reverse the Examiner's final rejection of Claims 1-20 so that this case may be allowed and pass to issue in a timely manner.

Respectfully submitted,

/James C. Pintner/

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CLAIMS APPENDIX (37 C.F.R. §41.37(c)(1)(viii))

1. A method for etching a III-V semiconductor material comprising:
placing a semiconductor substrate on which said III-V semiconductor material has been deposited into a reactive ion etching reactor;
introducing a first gas chosen from HBr, HI and IBr into said reactive ion etching reactor;
introducing a second gas of CH₄ into said reactive ion etching reactor;
introducing a third gas of H₂; and
exposing a portion of said III-V semiconductor material to be etched to a mixture comprising said first, said second and said third gas.
2. The method of Claim 1 further comprising the etching of vertical features into said III-V semiconductor material.
3. The method of Claim 1 wherein the percentage of said first gas is in the range from about 2 to 75 percent by volume.
4. The method of Claim 1 wherein the percentage of said second gas is in the range from about 5 to 50 percent by volume.
5. The method of Claim 1 wherein the percentage of said third gas is in the range from about 5 to 40 percent by volume.
6. The method of Claim 1 wherein said reactive ion etching reactor is maintained at a pressure in the range from about 1 to 30 mTorr.

7. The method of Claim 1 wherein the DC bias for said reactive ion etching reactor is in the range from about 100 to 500 volts.

8. The method of Claim 2 wherein said vertical features have an aspect ratio greater than ten.

9. The method of Claim 1 further comprising the step of growing a mask onto said III-V semiconductor material.

10. The method of Claim 9 wherein said mask comprises silicon.

11. The method of Claim 10 wherein said mask is made of Si_3N_4 .

12. A method for etching a III-V semiconductor substrate comprising:
placing said semiconductor substrate into a reactive ion etching reactor;
introducing a first gas chosen from HBr, HI and IBr into said reactive ion etching reactor;
introducing a second gas of CH_4 into said reactive ion etching reactor;
introducing a third gas of H_2 ; and
exposing a portion of said III-V semiconductor substrate to be etched to a mixture comprising said first, said second and said third gas.

13. The method of Claim 12 further comprising the step of etching vertical features into said III-V semiconductor material.

14. The method of Claim 12 wherein the percentage of said first gas is in the range from about 2 to 75 percent by volume.

15. The method of Claim 12 wherein the percentage of said second gas is in the range from about 5 to 50 percent by volume.

16. The method of Claim 12 wherein the percentage of said third gas is in the range from about 5 to 40 percent by volume.

17. The method of Claim 12 wherein said reactive ion etching reactor is maintained at a pressure in the range from about 1 to 30 mTorr.

18. The method of Claim 12 wherein the DC bias for said reactive ion etching reactor is in the range from about 100 to 500 volts.

19. The method of Claim 13 wherein said vertical features have an aspect ratio greater than ten.

20. The method of Claim 12 further comprising the step of growing a mask onto said III-V semiconductor substrate.

EVIDENCE APPENDIX (37 C.F.R. §41.37(c)(1)(ix))

None.

RELATED PROCEEDINGS APPENDIX (37 C.F.R. §41.37(c)(1)(x))

None.